NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD

WASTE TREATMENT LAGOON

(No.)
Code 359

DEFINITION

A waste treatment impoundment made by constructing an embankment and/or excavating a pit or dugout.

PURPOSE

To biologically treat organic waste, such as manure and wastewater, and to reduce its pollution potential as a treatment function component of an agricultural waste management system.

CONDITIONS WHERE PRACTICE APPLIES

- Where the lagoon is a component of a planned agricultural waste management system.
- Where treatment is needed for organic wastes generated by agricultural production or processing.
- On any site where the lagoon can be constructed, operated and maintained without polluting air or water resources.
- To lagoons utilizing embankments with an effective height of 35 feet or less where damage resulting from failure would be limited to damage of farm buildings, agricultural land, or township and country roads.

CRITERIA

Laws and regulations. All work shall comply with all Federal, state, and local laws and regulations. A waste treatment lagoon as may require a permit by the Florida Department of Environmental Protection (FDEP). Refer to Chapter 62-522 Florida Administrative Code (F.A.C.) and Chapter 62-670 F.A.C. for permitting requirements.

Location. To minimize the potential for contamination of streams, lagoons should be located outside of floodplains. However, if site restrictions require location within a floodplain, they shall be protected from inundation or damage from a 25-year 24-hr rainfall flood event, or a larger rainfall event if required by laws, rules, and regulations. Lagoons shall be located so the potential impacts from breach of embankment, accidental release, and liner failure are minimized; and separation distances are such that prevailing winds and landscape elements such as building arrangement, landforms, and vegetation minimize odors and protect aesthetic values.

Lagoons should be located so they have as little drainage area as possible. If a lagoon has a drainage area, the volume of normal runoff during the treatment period and 25-year, 24-hour storm event runoff shall be included in the required volume of the lagoon.

Waste treatment lagoons shall meet the minimum distance requirement from public or private facilities as shown in Table 1.

Hazard classification. The area downstream of the embankment shall be evaluated to

determine the impact of damage from a sudden breach of the proposed embankment on both structural and environmental features. This evaluation must consider all improvements and those improvements that may reasonably be expected to be made during the useful life of the structure. The results of this evaluation provides for the proper hazard approval classification of the embankment. Only hazard class (a) embankments are to be designed under this standard. See National Engineering Manual (NEM) Part 520.23 for guidance in documenting hazard classification.

Table 1 - Minimum Distance Requirement for Waste Treatment Lagoons

Public or Private Use Facilities	**Min. Distance From Lagoon**
Any public use area, church, picnic area, playground, etc.	300 feet
Residence or place of habitation other than owner or tenant	300 feet
Potable Wells, Private	100 feet
Potable Wells, Public	300 feet
Natural Water Courses	200 feet
Milking parlor	100 feet
Drainage Ditches	100 feet
Area specified by state or local ordinance	Greater of state or local distance or distance shown above

Soils and foundation. The lagoon shall be located in soils that can achieve a maximum allowable specific discharge of 0.0028 ft/day (1×10^{-6} cm/sec) or shall be sealed by mechanical treatment or by the use of an impermeable liner. Information and guidance on controlling seepage from wate impoundments can be found in the Agricultural Waste Management Field Handbook (AWMFH) Appendix 10D. Where possible, avoid sites with gravelly soils and shallow soils over fractured or cavernous rock. A detailed soils investigation with special attention to the water table depth and seepage potential must be considered in each design. Soil investigations must evaluate soils to a depth no less than two feet below the final grade of any excavation. In high risk areas, the procedures outlined in the AWMFH, page FL7-16a shall be followed.

Liners. Self-sealing ponds are not an acceptable means of containing waste, except as noted in the section "Lagoons constructed in high water table soils". The subgrade shall be a dense base regardless of liner method. The lagoon shall have a bottom elevation that is a minimum of 2 feet above the seasonal high water table unless special design features are incorporated that address buoyant forces, lagoon seepage rates, and non-encroachment of the water table by contaminants. The water table may be lowered by use of perimeter drains to meet this requirement. The lagoon shall be sealed by one of the liners as described below.

1. Compacted earth liners. Earth liners shall be designed in accordance with AWMFH Appendix 10D Geotehnical, Design, and Construction Guidelines for a maximum allowable specific discharge of 0.0028 ft/day.

   The soil shall be tested to determine the compaction and moisture requirements in order to not exceed the maximum allowable specific discharge.

   Compacted earth liners shall have a minimum thickness of 1 foot on lagoon side slopes and bottom measured perpendicular to the finished surface. The final liner thickness shall be determined using AWMFH Chapter 10, Appendix D. The liner material shall be placed in layers not over 9 inches thick and compacted to the required density to ensure the liner does not exceed the maximum allowable specific discharge. Moisture content before compaction shall be approximately 2 percent wet of optimum. Compaction requirements shall be verified in accordance with ASTM D 698.

   Compacted earth liners shall have side slopes of 3 horizontal to 1 vertical (3:1) or flatter, except where compacted earth liners are part of (brought up with) an earthfill operation. The compacted earth liner shall be covered with not less than 1 foot of compacted on-site material measured perpendicular to the finished surface. Compacted earth liners shall be protected from damage during initial filling operations.

2. Flexible membrane. A flexible membrane liner designed and constructed in

accordance with the Florida NRCS conservation practice standard Pond Sealing and Lining - Flexible Membrane, Code 521A.

3. Bentonite. A bentonite liner designed and constructed in accordance with the Florida NRCS conservation practice standard Pond Sealing and Lining - Bentonite Sealant, Code 521C.

4. Concrete. A concrete liner designed and constructed in accordance with NRCS Construction Specification 32, Concrete for Minor Structures and the following criteria:

   a. For side slopes and bottoms that will not have any vehicular traffic, use a minimum 4 inch thick concrete slab placed over a minimum 6 inch thick layer of granular material. The granular material shall be compacted to a density equal to at least 90 percent of the maximum density obtained in compaction tests of the fill performed by Method A, ASTM D 698. No joints are required. Wire mesh or fiber reinforcement is required.

   b. For concrete lined areas such as approaches, ramps and bottoms that will have vehicular traffic of any kind, use a minimum 5 inch thick concrete slab placed over a minimum 6 inch thick layer of granular material. The granular material shall be compacted to a density equal to at least 95 percent of the maximum density obtained in compaction tests of the fill performed by Method A, ASTM D 698. Concrete joints and reinforcement shall be as required by design analysis.

   c. Concrete lined side slopes shall be 2 horizontal to 1 vertical (2:1) or flatter, except for concrete push-off ramps. Concrete push-off ramp slopes shall be 1 horizontal to 1 vertical (1:1) or flatter on cut slopes and 2 horizontal to 1 vertical (2:1) or flatter on embankment slopes.

5. Natural clay base. In situ soils classified in permeability groups III or IV as defined in AWMFH Appendix 10D are acceptable provided they have a minimum thickness of 2 feet below the deepest excavation limits and are at dry densities equivalent to at least 90 percent Standard Proctor (ASTM D 698). The required minimum thickness of the natural clay base shall be determined using AWMFH Appendix 10D. Special precautions must be taken if the soils contain high amounts of calcium. Subsurface investigations must demonstrate that suitable natural soil material exists for the minimum depth required below the design bottom elevation of the lagoon and that no highly unfavorable geologic conditions occur at the site.

   Natural clay based liners shall have side slopes of 2 horizontal to 1 vertical (2:1) or flatter.

Lagoons constructed in high water table soils. Lagoons constructed in high water table soils shall be based on a detailed risk assessment. The risk assessment shall include an analysis of the potential for ground water pollution considering the hydrogeology, ground water transmissivity, soil permeability, etc. Decisions to install lagoons in high water table soils without liners must provide reasonable assurances that it will not cause surface or ground water pollution.

If during the risk assessment, it is determined that the site is a potential hazard to ground water pollution, it shall be designed with a liner to prevent contamination of ground water. Methods to maintain the liner integrity shall be included in the design.

Storage volume for waste treatment lagoons constructed in high water table soils shall be the volume above the natural high water level elevation.

Required volume. The required volume for lagoons shall include a volume or depth for the following:

1. Minimum treatment volume (anaerobic lagoons only).
2. Volume of manure, waste water, and other wastes accumulated during the hydraulic retention period.
3. Normal precipitation less evaporation on the surface area of the lagoon surface (at the required volume level) during the hydraulic retention period plus any runoff from drainage areas that enters the lagoon during the hydraulic retention period.

4. Volume of accumulated sludge for the period between sludge removal events (2 year minimum).
5. The 25-year, 24-hour storm precipitation on the surface area (at the required volume level) of the lagoon during the treatment period plus any runoff from drainage areas that enters the lagoon from the storm event.

Treatment period. The treatment period is the hydraulic detention time between supernatant drawdown events. It shall be the greater of either 60 days; the time required to store the supernatant for environmentally safe utilization considering the climate, crops, soil, and equipment requirements; or as required by local, state, and federal regulations.

Waste loading. Daily waste loading shall be based on the maximum daily loading considering all waste sources that will be treated by the lagoon. Design loading shall be based on the maximum weight of animals using the lagoon and on other waste introduced. Reliable local data or laboratory test data should be used if available. If local data is not available, Chapter 4 of the AWMFH should be used for estimating waste loading.

Treatment design. A lagoon's treatment function shall be designed on the basis of the 5-day biochemical oxygen demand (BOD_5) or volatile solids (VS) loadings as appropriate.

Embankment. The minimum elevation of the top of the settled embankment shall be 1 foot above the maximum design water surface in the lagoon. This height shall be increased by the amount needed to ensure that the design top elevation will be maintained after settlement. This increase shall not be less than 5 percent. The combined side slopes of the settled embankment shall not be less than 5 horizontal to 1 vertical (5:1) and neither slope shall be steeper than 2 horizontal to 1 vertical (2:1) unless special provisions are made to provide stability. The minimum top width shall be as shown in Table 2.

Table 2 - Embankment Top Width

Total height of embankment, ft	Top width, ft
<15	8
15 to <20	10
20 to <25	12
25 to <30	14
30 to 35	15

Compaction of the embankment fill material shall be in accordance with the specified design requirements for compaction and moisture content. As a minimum, compaction shall be equivalent to, or better than, the following:

Layers of fill shall not exceed 9 inches in thickness before compaction. Compaction shall be accomplished by routing the hauling and spreading equipment over the fill in such a manner that every point on the surface of each layer of fill will be traversed by not less than two tread tracks of the loaded equipment traveling in a direction parallel to the main axis of the fill.

Clayey soils shall be compacted with a "sheepsfoot" or tamping roller. (AWMFH Appendix 10D).

Excavations. Excavated side slopes shall be stable and not less than 2 horizontal to 1 vertical (2:1) unless provisions are made to provide stability. The bottom of aerobic lagoons shall be approximately level.

Auxiliary spillway. Lagoons having a maximum design liquid level of 3 feet or more above natural ground (embankment) shall be provided with an auxiliary spillway, overflow structure, or combination to protect the lagoon from overtopping.

Embankment lagoons with a drainage area shall have an auxiliary spillway, overflow structure, or combination sized to protect the lagoon from overtopping when a 25-year, 24-hour storm event is exceeded and the design volume of the lagoon is filled. The crest of the auxiliary spillway or overflow structure shall be located at or above the same elevation as the top of the 25-year, 24-hour storm storage. The auxiliary spillway or overflow structure shall be designed to pass a 25-year, 24-hour storm without overtopping the embankment. The settled top of the embankment shall be a minimum of 1 foot

above the designed depth of flow in the lagoon with the auxiliary spillway or overflow structure operating at the design discharge.

Embankment lagoons without a drainage area shall have an auxiliary spillway, overflow structure, or combination sized to handle the maximum design inflow rate to the lagoon. The crest of the auxiliary spillway or overflow structure shall be located at or above the same elevation as the top of the 25-year, 24-hour storm storage. The settled top of the embankment shall be a minimum of 1 foot above the designed depth of flow in the lagoon with the auxiliary spillway or overflow structure operating at the design discharge.

Inlet. Inlets shall be designed in accordance with Florida conservation practice standard Manure Transfer, Code 634.

Outlet. All outlets shall be designed in accordance with Florida NRCS conservation practice standard Manure Transfer.

Facility for drawdown. A structure shall be provided for drawing down the supernatant level in the lagoon. It may be a dock, a pumping platform, a retaining wall, or a ramp. Draw down shall not cause erosion or damage to liners. Ramps used to withdraw supernatant shall have a slope of 4 horizontal to 1 vertical (4:1) or flatter.

Where agitators are used in lagoons with liners, the tip of the propeller shall be a minimum of 3 feet from the liner surface or the liner shall be protected by a concrete pad.

Sludge removal. Provision shall be made for removal of accumulated sludge to preserve the treatment capacity of the lagoon. The anticipated method for accomplishing this must be considered in determining the size and shape of the lagoon and type of liner.

Waste application. All waste removed from the lagoon shall be utilized in accordance with Florida NRCS conservation practice standard Waste Utilization, Code 633 and/or Nutrient Management, Code 590.

Protection. To control erosion, embankments and disturbed areas surrounding the lagoon shall be vegetated according to Florida NRCS conservation practice standard Critical Area Planting, Code 342.

Safety. Designs shall include appropriate safety features to minimize the hazards of the lagoon. The lagoon shall be fenced and warning signs posted to prevent children and others from using it for purposes other than its intended purpose. Fencing shall meet the requirements of Florida NRCS conservation practice standard Fence, Code 382.

Additional Criteria for Anaerobic Lagoon

Loading rate. Anaerobic waste treatment lagoons shall be designed to have a minimum treatment volume based on VS loading per unit of volume. The maximum loading rate shall be as indicated in Figure 10-22 of the AWMFH or according to state regulatory requirements, whichever is more stringent. If a high degree of odor control is necessary, loading rates should be decreased.

Operating levels. The maximum operating level shall be the required volume less the 25-year, 24 hour storm event precipitation on the surface of the lagoon plus any runoff from drainage areas that enters the lagoon from the storm event. The maximum operating level shall be marked with an appropriate staff gage set in the lagoon or by other means to indicate when drawdown is needed. The maximum drawdown shall be the level of the combined accumulated sludge volume and minimum treatment volume. A permanent marker shall be installed at this elevation to indicate when drawdown is to cease. These markers shall be referenced and described in the O&M plan.

The minimum operating level after drawdown should normally be the minimum treatment volume plus sludge volume except when the lagoon is in drawdown to permit sludge removal or addition of dilution water.

Depth requirements. The minimum depth at maximum drawdown shall be 6 feet. If subsurface conditions prevent practicable construction to accommodate the minimum depth at maximum drawdown, a lesser depth may be used if the volume requirements are met.

Additional Critereia for Naturally Aerobic Lagoon

Loading rate. Naturally aerobic lagoons shall be designed to have a minimum treatment surface area determined on the basis of daily BOD_5 loading per unit of lagoon surface. The maximum loading rate shall be as indicated in Figure 10-25 of the AWMFH or according to

state regulatory requirements, whichever is more stringent.

Operating levels. The maximum operating level shall be the required volume less the 25-year, 24-hour storm event precipitation on the lagoon surface plus any runoff from drainage areas that enters the lagoon from the storm event. The maximum level shall be marked with an appropriate staff gage set in the lagoon or by other means to indicate when drawdown is needed. The maximum drawdown shall be to the level of the combined volume of accumulated sludge between sludge removal events and volume of manure, wastewater, and clean water accumulated during the treatment period. A permanent marker shall be installed at this elevation to indicate when drawdown is to cease. Theses markers shall be referenced and described in the O&M plan.

Depth requirements. The depth at maximum operating level shall be 5 feet maximum and 2 feet minimum. The depth at maximum drawdown shall not be less than 2 feet.

Additional Criteria for Mechanically Aerated Lagoon

Loading rate. Mechanically aerated lagoons' treatment function shall be designed on the basis of daily BOD_5 loading and aeration equipment manufacturer's performance data for oxygen transfer and mixing. Aeration equipment shall provide a minimum of 1 pound of oxygen for each pound of daily BOD_5 loading.

Operating levels. The maximum operating level shall be the required lagoon volume less the 25-year, 24-hour storm event precipitation plus any runoff from drainage areas that enters the lagoon from the storm event and shall not exceed the site and aeration equipment limitations. The maximum level shall be marked with an appropriate staff gage set in the lagoon or by other means to indicate when drawdown is needed. These markers shall be referenced and described in the O&M plan.

Depth requirements. The depth at maximum operating level shall be 5 feet maximum and 2 feet minimum. The depth at maximum drawdown shall not be less than 2 feet.

CONSIDERATIONS

General

Waste treatment lagoons are of three general types (1) anaerobic, (2) naturally aerobic, and (3) mechanically aerated. Anaerobic lagoons require less surface area than naturally aerobic lagoons but may give off odors. Naturally aerobic lagoons are relatively odor free. Mechanically aerated lagoons are comparable in size to anaerobic lagoons and are generally odor free, but they require energy for aeration.

To reduce sludge buildup, remove solids from waste of animals, such as dairy cattle that are fed high roughage rations. A solids trap or a separator may be provided between the waste sources and the lagoon. This may be a concrete or earth structure that can be emptied periodically. Settling facilities should have adequate capacity to store settled solids for a time period based on climate, equipment, clean out frequency, and method of disposal. Solid separators, debris basins, etc., shall be designed to prevent seepage to the groundwater.

The configuration of the lagoon should be based on the method of sludge removal and method of sealing.

For sites located in rural areas where odors would affect neighboring farms having enterprises that do not cause odors and/or neighbors who earn a living off-farm, consideration should be given to design of anaerobic lagoons with loading rates reduced to at least one-half of the values shown in AWMFH Figure 10-22.

For sites located near urban areas, the following should be considered:

- Covering the lagoon with a suitable liner.
- Using naturally aerated or mechanically aerated lagoons.
- Using composting in conjunction with a solid waste system rather than a liquid or slurry system.
- Using a methane digester and capture system.

Vegetative screens or other methods should be used to shield the lagoon from public view and to improve visual conditions.

Lagoons should be located as close to the source of waste and polluted runoff as practicable.

Due consideration should be given to economics, the overall waste management system plan, and safety and health factors.

Considerations for minimizing the potential for and impacts of sudden breach of embankment or accidental release from the required volume

Features, safeguards, and/or management measures to minimize the risk of embankment failure or accidental release, or to minimize or mitigate impact of this type of failure should be considered when any of the categories listed in Table 3 might be significantly affected.

The following should be considered either singly or in combination to minimize the potential of or the consequences of sudden breach of embankments when one or more of the potential impact categories listed in Table 3 may be significantly affected:

- An auxiliary (emergency) spillway.
- Additional freeboard.
- Storage volume for the wet year rather than normal year precipitation.
- Reinforced embankment -- such as, additional top width, flattened and/or armored downstream side slopes.
- Secondary containment.
- Water level indicators or recorders.

Table 3 - Potential Impact Categories from Breach of Embankment or Accidental Release

1. Surface water bodies -- perennial streams, lakes, wetlands, and estuaries.
2. Critical habitat for threatened and endangered species.
3. Riparian areas.
4. Farmstead, or other areas of habitation.
5. Off-farm property.
6. Historical and/or archaeological sites or structures that meet the eligibility criteria for listing in the National Register of Historical Places.

The following should be considered to minimize the potential for accidental release from the required volume through gravity outlets when one or more of the potential impact categories listed in Table 3 may be significantly affected:

- Outlet gate locks or locked gate housing
- Secondary containment
- Alarm system
- Another means of emptying the required volume

Considerations for minimizing the potential of lagoon liner seepage

Consideration should be given to providing an additional measure of safety from lagoon seepage when any of the potential impact categories listed in Table 4 may be affected.

Table 4 - Potential Impact Categories for Liner Seepage

1. Any underlying aquifer is at a shallow depth and not confined.
2. The vadose zone is rock.
3. The aquifer is a domestic water supply or ecologically vital water supply.
4. The site is located in an area of carbonate rock (limestone or dolomite).

Should any of the potential impact categories listed in Table 4 be affected, consideration should be given to the following:

- A clay liner designed in accordance with procedures of AWMFH, Appendix 10D with a thickness and coefficient of permeability so that specific discharge is less than 1×10^{-6} cm/sec.
- A flexible membrane liner
- A geosynthetic clay liner (GCL) flexible membrane liner
- A concrete liner designed in accordance with slabs on grade criteria in Florida NRCS Practice Standard 313, Waste Storage Facility, for fabricated structures requiring water tightness.

Considerations for Improving Air Quality

To reduce emissions of greenhouse gases, ammonia, volatile organic compounds, and odor:

- Reduce the recommended loading rate for anaerobic lagoons to one-half the values given in AWMFH Figure 10-22.
- Use additional conservation practices such as Covered Anaerobic Digester, Ambient Temperature, Code 365, Anaerobic Digester, Controlled Temperature, Code 366, and Composting Facility, Code 317 in the waste management system.
- Design lagoons to be naturally aerobic or to allow mechanical aeration.

Adjusting pH below 7 may reduce ammonia emissions from the lagoon but may increase odor when waste is surface applied (See Florida NRCS conservation practice standard Waste Utilization, Code 633).

PLANS AND SPECIFICATIONS

Plans and specifications shall be prepared in accordance with the criteria of this standard and shall describe the requirements for applying the practice to achieve its intended use.

Engineering plans, specification and reports shall include but not limited to the following:

1. Plan view of system layout.
2. Typical cross sections of lagoon.
3. Construction specifications.
4. Type and number of animals the structure is designed to serve.
5. Structural details of all components.
6. References of components supplied by others (pumps, etc.).
7. Special safety requirements.
8. Vegetative requirements.
9. Quantities.
10. Drainage/grading plan if one is needed.
11. Soil and foundation findings, interpretations, and reports.
12. Temporary erosion control measures during construction.
13. Odor management and minimization requirements.

OPERATION AND MAINTENANCE

An operation and maintenance plan shall be developed that is consistent with the purposes of the practice, its intended life, safety requirements, and the criteria for its design. The waste storage facility should be inspected periodically to ensure that all components are operating as planned.

The O&M plan shall contain the operational requirements for supernatant drawdown. It shall include maximum operating and other operating levels and reference to the staff gauge(s). O&M requirements shall be provided for all structural components (concrete, pumps, etc.).

The O&M plan shall include the requirement that waste shall be removed and utilized at locations, times, rates, and volume in accordance with Florida NRCS conservation practice standard Waste Utilization, Code 633 and/or Nutrient Management, Code 590. Records shall be kept of the amount of waste applied, location and acres where applied, and the date waste was applied.

The lagoon shall be operated so as to maintain the storage capacity for the 25-year, 24-hour storm.

The embankment and other vegetated areas shall be mowed and fertilized to maintain a protective vegetative cover.

REFERENCES

ASTM D 698
AWMFH Appendix 10D
FDEP Chapter 62-522 F.A.C. and 62-670 F.A.C.
Florida NRCS Conservation Practice Standards
- Anaerobic Digester, Controlled Temperature, Code 366
- Covered Anaerobic Digester, Ambient Temperature, Code 365
- Critical Area planting, Code 342
- Manure Transfer, Code 634
- Nutrient Management, Code 590
- Pond, Code 378
- Pond Sealing and Lining - Flexible Membrane, Code 521A
- Pond Sealing and Lining - Bentonite Sealant, Code 521C
- Waste Utilization, Code 633
- NRCS Construction Specification, 32, Concrete for Minor Structures

NEM, Part 520.23